COMPARATIVE ANALYSIS OF AIRPORT PAVEMENT DESIGN PROCEDURES

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ABSTRACT

A comparative analysis of the results of different design methods is a powerful tool for the evaluation and development of new pavement design procedures. A sensitivity, or comparative, analysis was employed during the development of FAA Advisory Circular 150/5320-16[1] and its computer program LEDFAA. FAA is currently developing a new Portland cement concrete (PCC) design procedure based on the 3D finite element method and has modified the original subgrade vertical strain based failure criteria used for flexible pavement design.

The comparative analysis results will be used to calibrate the parameters to be used in the new failure models and to provide guidance on the selection of design inputs. This study included comparison and evaluation of both new construction and overlay designs over a broad range of input conditions.

Since the FAA design procedure requires the use of a stabilized base and subbase for airport pavements accommodating aircraft heavier than 100,000 lbs, the sensitivity of a stabilized base/subbase on the pavement life or thickness has also been studied. Design thickness comparisons, using different models, are provided to show how the sensitivity analysis results influence the design model.

Since the fundamental models governing the design procedures can best be evaluated in the context of designs for new pavement structures, this paper focuses on the results of the comparative analyses for new pavements. Overlay design comparisons are still on-going, but can essentially be considered a subsystem of the new pavement design procedures.

Other parameters analyzed in this study included subgrade strength, aircraft type, annual departure levels for single aircraft, narrow-body and wide-body aircraft traffic mixes, and thickness and strength of stabilized and aggregate base and subbase layers. Numerical sensitivity comparisons among different failure models included in standard FAA layered elastic (LEDFAA) and conventional design methods (FAA Advisory Circular 150-5320/6D[2]) have also been conducted. It has been found that, under certain conditions, computational results can differ, depending on the model and the range of input parameters that were evaluated. The need to standardize reasonable ranges in inputs with respect to computational differences should be fully considered in calibrating the parameters used in the new design procedure.

INTRODUCTION

The FAA is currently focusing the development of its new design procedures for airport pavement on mechanistic analytical methods. As discussed by Brill, et al[3], the new design procedures will employ layered elastic design methods for flexible pavements and finite element methods for rigid pavement. The integrated design procedures will ultimately be incorporated in the FAA Rigid and Flexible Interactive Elastic Layer Design (FAARFIELD) program, scheduled for release in 2006.

FAA's LEDFAA program discussed in Chapter 7 of Advisory Circular 150/5320-6D and Advisory Circular 150/5320-16 currently uses layered elastic design procedures as an optional design procedure for both rigid and flexible pavements.

The advisory circulars still allow the use of the California Bearing Ratio (CBR) and Westergaard's design procedures for both flexible and rigid pavements, respectively.

In 2003, the FAA modified the subgrade strain failure model for flexible pavement design and incorporated the new model, as well as other changes, in Version 1.3 of LEDFAA. Hayhoe[4] discussed the modifications to the flexible pavement failure model using the results of full-scale flexible pavement tests at the FAA's National Airport Pavement Test Facility (NAPTF).

The Finite Element Design Federal Aviation Administration (FEDFAA) software program is the FAA's new design procedure for airport pavements. FEDFAA includes an improved layered elastic analysis routine for flexible pavement design, and a three dimensional (3D) finite element (FE) structural analysis routine for rigid pavement design. LEDFAA will overcome one of the major disadvantages associated with rigid pavement design inherent in FAA's layered elastic design program, LEDFAA**,** by allowing direct computation of slab edge stresses.

Until the FAA completes full scale testing of flexible and rigid pavements at the NAPTF, it is necessary to compare the results of FEDFAA to current FAA pavement design standards contained in Advisory Circular 150/5320-6D. Since the original pavement design procedures were based on the results of full-scale tests, comparisons to the existing design standards can serve as a backward validation to the original full-scale tests until new full-scale tests are completed and fully integrated into the prior full scale test results. This approach was taken by McQueen, et al[5] during the development of FAA's LEDFAA program.

COMPARATIVE ANALYSIS TEST MATRIX

As standard set of pavement structures and traffic mixes were developed to fully exercise the new design procedures over a wide range of design conditions for new flexible and rigid pavements. The comparative results were recorded in a spreadsheet program and will be posted on the FAA Technical Center website.

An eight character naming convention was developed to rapidly identify the general characteristics of the pavement structure and the traffic mix or single aircraft used in the sensitivity study. In the example, structure ROGL1T01:

- The first character indicates the type of pavement (Rigid or Flexible).
- The second character indicates New, Flexible Overlay, Rigid Unbonded Overlay or Rigid Partial Bond Overlay.
- The third character indicates the type of base/subbase layer (Granular, Stabilized).
- The fourth character indicates the subgrade strength (Very Low, Low, Medium, and High).
- The fifth character indicates the number of base/subbase layers (1 or 2).
- The last three characters indicate the Single aircraft type or Traffic mix number.

New Flexible Pavement Test Structures

Twelve (12) pavement structures were selected for the new flexible pavement design testing and are presented in Table 1. A short description of the chosen pavement structures is presented below:

- Pavement structures 1, 2, 3, and 4 are on low-strength subgrade (CBR=4). Medium-strength subgrade (CBR=8) is used in pavement structures 5, 6, 7, and 8. Pavement structures 9, 10, 11, and 12 are on high-strength subgrade (CBR=15).

- Pavement structures 1, 5, and 9 have 8-inch thick P-209, "Crushed Aggregate Base Course" and pavement structures 2, 6, and 10 have 12-inch thick P-209 base. Minimum base thickness requirement is 8 inches for crushed stone base (as per Advisory Circular 150/5320-6D). The remaining pavement structures have 5-inch and 8-inch stabilized base

- P-401 asphalt concrete surface thickness for all pavement structures is 5 inches.

Conversion to subgrade elastic modulus, E, and CBR, were based on correlations contained in Advisory Circular 150/5320-6D, $E_{(psi)}$ = 1500 CBR.

Table 1.
Pavement Structural Data (New Flexible Pavement Design)

Pavement Structure	P-401 Surface		Base		Subgrade		Comments
	Thickness, inch	E, psi	Thickness, inch	E, psi	CBR	E, psi	
1	5	200000	8	*	4	6000	
2	5	200000	12	*	4	6000	
3	5	200000	5	400000	4	6000	ASB
4	5	200000	8	400000	4	6000	ASB
5	5	200000	8	*	8	12000	
6	5	200000	12	*	8	12000	
7	5	200000	5	400000	8	12000	ASB
8	5	200000	8	400000	8	12000	ASB
9	5	200000	8	*	15	22500	
10	5	200000	12	*	15	22500	
11	5	200000	5	400000	15	22500	ASB
12	5	200000	8	400000	15	22500	ASB
* Modulus calculated by LEDFAA							
ASB - Asphalt Stabilized Base							

New Rigid Pavement Test Structures

Twenty (20) pavement structures were selected for the comparative study for new rigid pavement design testing and are summarized in Table 2.

Table 2.
Pavement Structural Data for Major Program Testing (New PCC Design)

Pavement Structure	Run No.	Subbase 1				Subbase 2			Subgrade		Foundation Top k (pci)
		Flexural Strength R, psi (MPa)	Thickness, inches (mm)	Elastic Modulus E, psi (MPa)	Poisson's Ratio	Thickness, inches (mm)	Elastic Modulus E, psi (MPa)	Poisson's Ratio	Elastic Modulus E, psi (MPa)	Poisson's Ratio	
1	A	647 (4.5)	6 (152)	14474 (100)	0.35	0	N/A	N/A	4500 (31)	0.35	85
2	22	647 (4.5)	6 (152)	21404 (148)	0.35	0	N/A	N/A	7500 (52)	0.35	124
3	23	647 (4.5)	6 (152)	250000 (1724)	0.25	6 (152)	21404 (148)	0.35	7500 (52)	0.35	241
4	26	647 (4.5)	6 (152)	500000 (3447)	0.25	6 (152)	21404 (148)	0.35	7500 (52)	0.35	241
5	29	647 (4.5)	6 (152)	35429 (244)	0.35	0	N/A	N/A	15000 (103)	0.35	199
6	30	647 (4.5)	6 (152)	250000 (1724)	0.25	6 (152)	35429 (244)	0.35	15000 (103)	0.35	304
7	33	647 (4.5)	6 (152)	500000 (3447)	0.25	6 (152)	35429 (244)	0.35	15000 (103)	0.35	304
8	36	647 (4.5)	6 (152)	49985 (344)	0.35	0	N/A	N/A	25000 (172)	0.35	264
9	37	647 (4.5)	6 (152)	250000 (1724)	0.25	6 (152)	49985 (344)	0.35	25000 (172)	0.35	340
10	40	647 (4.5)	6 (152)	500000 (3447)	0.25	6 (152)	49985 (344)	0.35	25000 (172)	0.35	340
11	B	700 (4.8)	6 (152)	14474 (100)	0.35	0	N/A	N/A	4500 (31)	0.35	85
12	22A	700 (4.8)	6 (152)	21404 (148)	0.35	0	N/A	N/A	7500 (52)	0.35	124
13	29B	700 (4.8)	6 (152)	35429 (244)	0.35	0	N/A	N/A	15000 (103)	0.35	199
14	36B	700 (4.8)	6 (152)	49985 (344)	0.35	0	N/A	N/A	25000 (172)	0.35	264
15	23A	647 (4.5)	6 (152)	700000 (4826)	0.25	6 (152)	21404 (148)	0.35	7500 (52)	0.35	241
16	30A	647 (4.5)	6 (152)	700000 (4826)	0.25	6 (152)	35429 (244)	0.35	15000 (103)	0.35	304
17	37A	647 (4.5)	6 (152)	700000 (4826)	0.25	6 (152)	49985 (344)	0.35	25000 (172)	0.35	340
18	23B	700 (4.8)	6 (152)	700000 (4826)	0.25	6 (152)	21404 (148)	0.35	7500 (52)	0.35	241
19	30B	700 (4.8)	6 (152)	700000 (4826)	0.25	6 (152)	35429 (244)	0.35	15000 (103)	0.35	304
20	37B	700 (4.8)	6 (152)	700000 (4826)	0.25	6 (152)	49985 (344)	0.35	25000 (172)	0.35	340

Pavement structures 1 to 10 and 15 to 17 have flexural strengths of 647 psi (4.5 MPa), with the remainder of the structures designed with flexural strength of 700 psi (4.8 MPa). The following is a short description of each structure:

- Pavement structures 1 and 2 utilize a single crushed granular subbase. The subgrade strength is variable with CBR=3 (very low) and CBR=5 (low), respectively.

- Pavement structures 3 and 4 utilize a 6-inch (152 mm) stabilized subbase (P-301, “Soil Cement Base” and P-304, “Cement Treated Base”, respectively) on top of the same granular subbase and subgrade in pavement structure 2.

- Pavement structure 5 has a single crushed granular subbase and a subgrade strength equivalent to CBR=10 (medium).

- Pavement structures 6 and 7 utilize a stabilized subbase (P-301 and P-304, respectively) on top of the same granular subbase and subgrade in pavement structure 5.

- Pavement structure 8 has a single crushed granular subbase and subgrade with a 16.7 CBR (high).

- Pavement structures 9 and 10 utilize a stabilized subbase (P-301 and P-304, respectively) on top of the same granular subbase and subgrade in pavement structure 8.

- Pavement structures 15, 16, and 17 are similar to pavement structures 12, 13, and 14, respectively, but have an additional stabilized subbase (P-306, “Econocrete”) with Young’s Modulus E = 700000 psi (4826 MPa).

Conversions to subgrade elastic modulus, E, and modulus of subgrade reaction, k, were based on the correlations contained in Advisory Circular 150/5320-6D, $E_{(\text{psi})} = 26\ k^{1.284}$

Aircraft Traffic Mixes

Eight (8) different traffic mixes were used to design the new rigid pavement structures. The mixes include both narrow-body and wide-body mixes from the following civil airports:

Mix 1 – Sarasota-Bradenton Airport (narrow-body)
Mix 2 – Washington-Dulles International Airport, Taxiway W-1 (wide-body)
Mix 3 – Washington Dulles International Airport, Runway 1L (wide-body)
Mix 4 – Memphis International Airport, Runway 18R (wide-body)
Mixes 5 and 6 – Charlotte-Douglas Airport (narrow-body)
Mix 7 – Philadelphia International Airport (wide-body)
Mix 8 – J.F. Kennedy International Airport (wide-body)

Mixes 3, 4, and 8 include B-777 aircraft and mix 8 includes A-380 aircraft.

In addition, to gauge the contribution of different aircraft gear configurations and operational frequencies, additional comparisons were performed for dual wheel (B-727 and B-737), dual tandem (DC-10), and triple tandem (B-777 and A-380) gears at varying annual departure levels shown in Tables 3a and 3b.

Table 3a.
Single Aircraft Data for Sensitivity Study and Complete Program Testing for New PCC and Overlay on Existing PCC Pavements

No.	Aircraft	Gross Weight, lbs	Annual Passes
1	B727-Low	209,000	1200
2	B727-Med	209,000	6000
3	B727-High	209,000	25000
4	DC-10-10-Low	460,000	1200
5	DC-10-10-Med	460,000	6000
6	DC-10-10-High	460,000	25000
7	B737-800-Low	173,000	1200
8	B737-800-Med	173,000	6000
9	B737-800-High	173,000	25000
10	B777-200 B-Low	653,000	1200
11	B777-200 B-Med	653,000	6000
12	B777-200 B-High	653,000	25000

Table 3b.
Single Aircraft Data for Sensitivity Study and Complete Program Testing for New Asphalt (AC) And Overlay on Existing AC Pavements

No.	Aircraft	Gross Weight, lbs	Annual Passes
13	A380-800-Low	1,239,000	120
14	A380-800-Med	1,239,000	1200
15	A380-800-High	1,239,000	12000
16	A-340 BELLY-Low	600,000	120
17	A-340 BELLY- Med	600,000	1200
18	A-340 BELLY -High	600,000	12000
19	B777-200 A-Low	537,000	120
20	B777-200 A-Med	537,000	1200
21	B777-200 A-High	537,000	12000
22	B747-400 -Low	873,000	120
23	B747-400 -Med	873,000	1200
24	B747-400 -High	873,000	12000

Pavement Design Methods

As discussed, the comparison of design thicknesses utilized the following design methods:

- Conventional Westergaard, as described in Advisory Circular 150/5320-6D (6D);
- Layered Elastic, as described in Advisory Circular 150/5320-6D (LEDFAA); and
- Finite Element, using the beta version of the FAA's FEDFAA program.

NEW RIGID PAVEMENT DESIGN RESULTS

The PCC slab thicknesses for new rigid pavements have been calculated using the three design procedures: 6D, LEDFAA, and FEDFAA, for the 20 pavement structures shown in Table 2, the single aircraft in Table 3a, and the eight traffic mixes. The results are divided in single aircraft and aircraft mixes.

Single Aircraft - Departure Level

Four single aircraft under different departure levels were considered. Figure 1 presents the difference between the thicknesses calculated by FEDFAA-6D and FEDFAA-LEDFAA. For dual gears (B727 and B737) the difference decreases when the annual passes increases and for dual- and triple-tandem gear (DC10-10 and B777) the differences increases when the annual passes increases for the FEDFAA-6D case. However, for the FEDFAA-LEDFAA case the thickness difference variation is very small. It increases by 0.1-inch for the B727 and DC10-10, decreasing 0.1-inch for B737 and decreasing by 0.2-inch for the B777 when the annual passes increases. The average thickness difference is -0.6-inch for FEDFAA-LEDFAA case and 1.2-inch for FEDFAA-6D case.

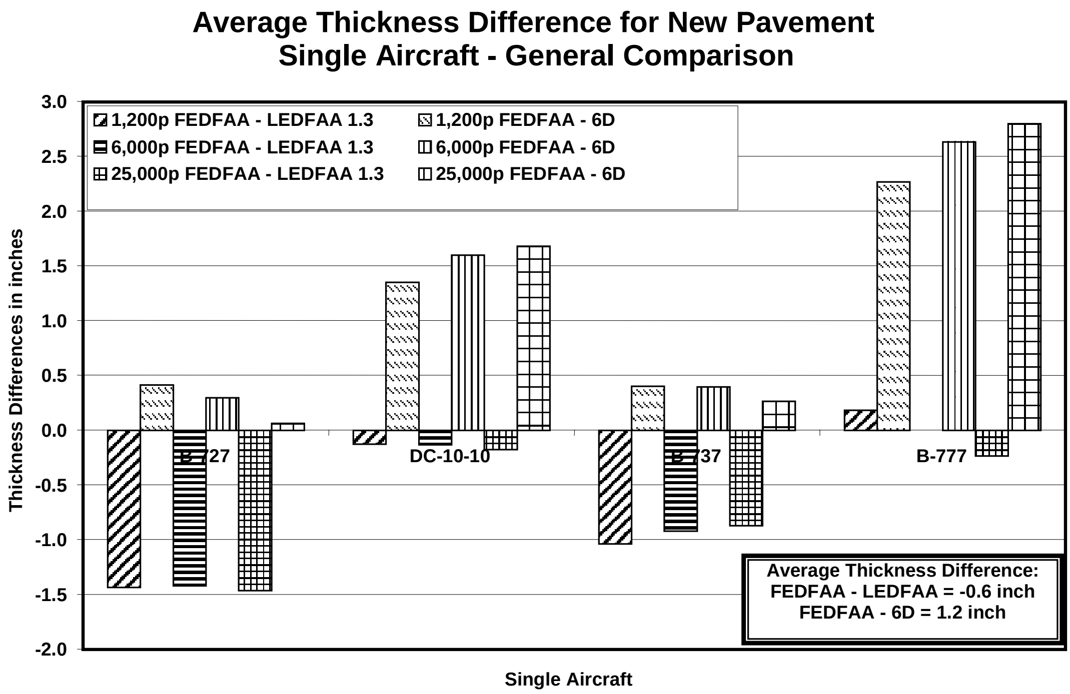

Figure 1. Thickness Difference between FEDFAA-LEDFAA and FEDFAA-6D

Single Aircraft – Subgrade Strength

Figure 2 shows the subgrade strength effect on thickness sensitivity for the four single aircraft under 6,000 annual departures as calculated by 6D, LEDFAA, and FEDFAA:

- For a pavement built on very weak subgrade, the damaging potential of aircraft is: B-777, B-727, DC-10-10, B-737. For a pavement built on very strong subgrade (E=4,500 psi), the relative damage for each aircraft is: B-727, B-737, DC-10-10, and B-777. This is true for 6D, LEDFAA, and FEDFAA for all cases, except for FEDFAA the relative damages for pavements on strong subgrade (E=25,000 psi) is: B-727, B-777, B-737, and DC-10-10.

- The slopes of the best fit lines in Figure 2 indicate the sensitivity of subgrade E value for the different design procedures. The design thickness is most sensitive to the subgrade E value for pavement designed for B-777 using LEDFAA. The relative sensitivity for B-777 aircraft by design procedure is: LEDFAA, 6D, and FEDFAA.

- It seems that the sensitivities of subgrade E value are relatively similar for B-727 and B-737 aircraft (dual gear), regardless of the design procedure used. However, they seem to be more sensitive to the subgrade E value in FEDFAA than the other design procedures.

- The sensitivity of subgrade E for DC10-10 and B-777 (dual- and tridem-tandem gear) is higher than for B-727 and B-737 (dual gear).

- From the single aircraft analysis it can be predicted what would happen when a traffic mix contains all above four aircrafts with similar number of annual departures. If the pavement is built on a very weak subgrade, its failure will be dominated by B-777; and if the pavement is built on a very strong subgrade, its failure will be dominated by B-727. If the pavement is built on a subgrade 7,500 psi < E < 15,000 psi (5 < CBR < 10), all aircraft will contribute to the pavement damage.

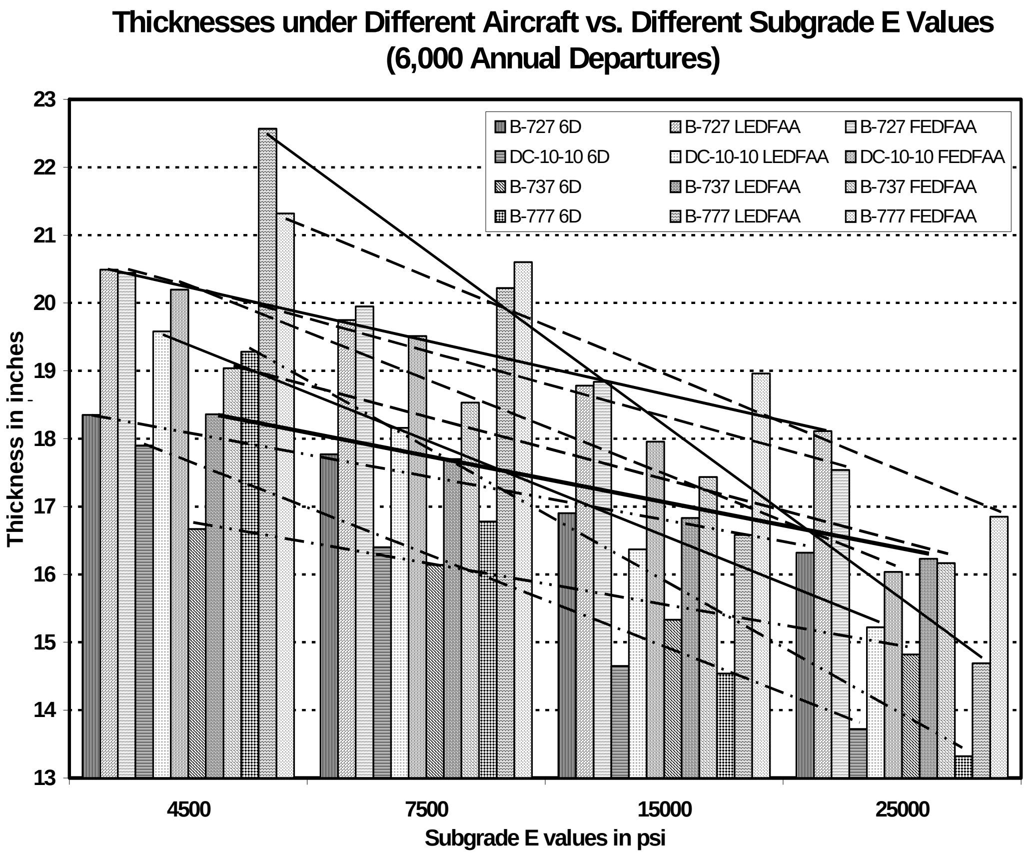

Figure 2. Thickness Sensitivity for Single Aircraft and Subgrade Strength

Single Aircraft - Thickness Correlation

- Figures 3 and 4 show the correlation of the design thickness by FEDFAA-6D and FEDFAA-LEDFAA, respectively, for the B-727 aircraft. The average thickness difference decreases for FEDFAA-6D but increases for FEDFAA-LEDFAA when the annual departures increase. Similar behavior was observed for the B-737.

- However, for the DC-10-10 and B-777 the average thickness differences exhibit an opposite behavior. The thickness difference for FEDFAA-6D increases and for FEDFAA-LEDFAA decreases when the annual passes increases.

- The R^2 values for B-727, B-737, DC-10-10, and B-777 are between 0.79 and 0.85 for the thickness correlation by FEDFAA-LEDFAA, and between 0.63 and 0.82 for thickness correlation predicted by FEDFAA-6D.

- Figure 5 shows the correlation FEDFAA-6D and FEDFAA-LEDFAA for all annual passes for the B-727 aircraft. The R^2 value for FEDFAA-6D is 0.67 and 0.81 for FEDFAA-LEDFAA. For all annual passes the predicted design thicknesses are better correlated for FEDFAA-LEDFAA than FEDFAA-6D.

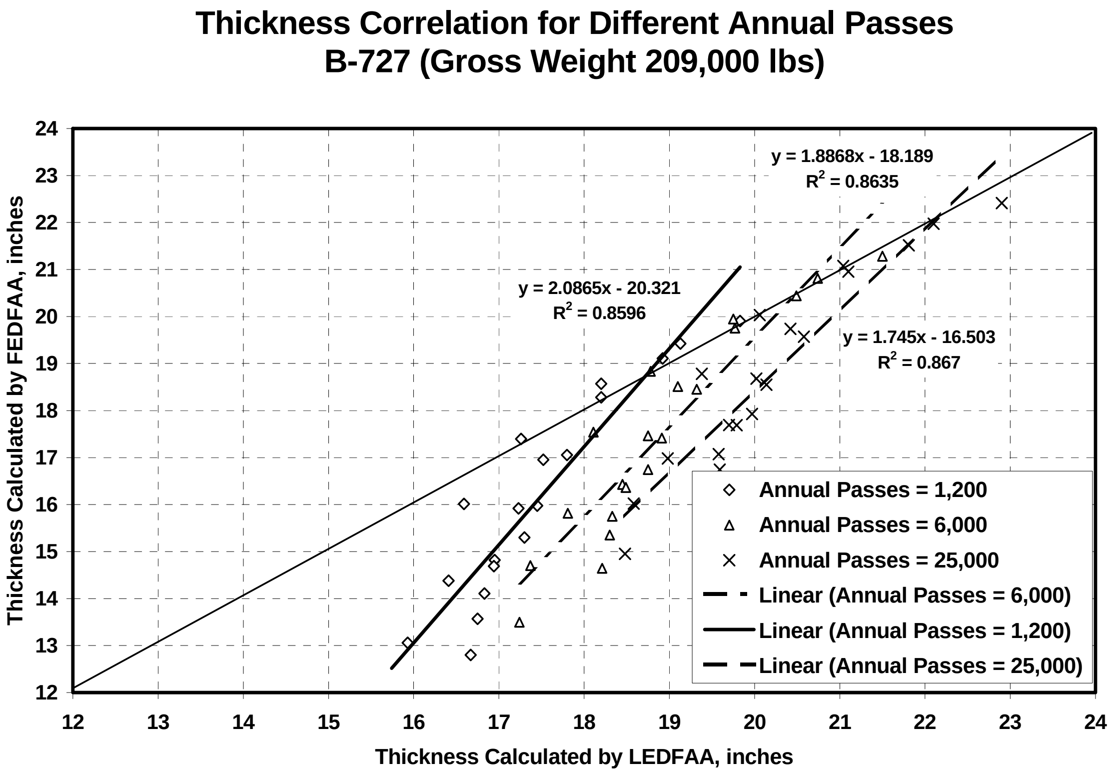

Figure 3. B-727 FEDFAA-6D Correlation, Wheel Load 49,638 lbs

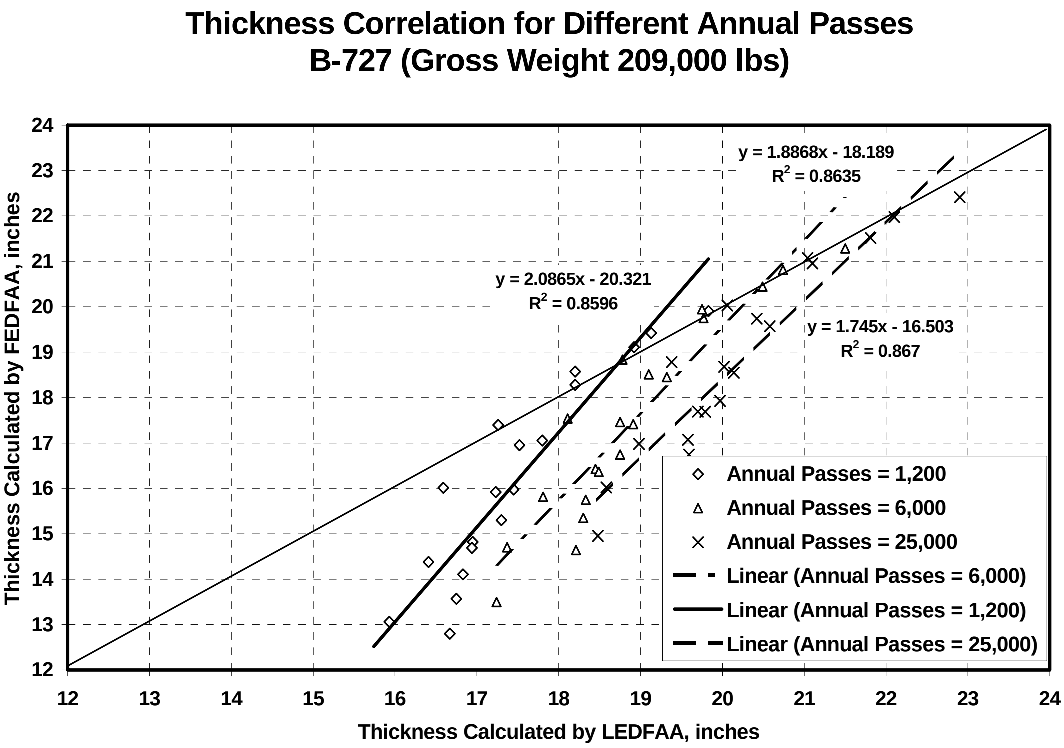

Figure 4. B-727 FEDFAA-LEDFAA Correlation, Wheel Load 49,638 lbs

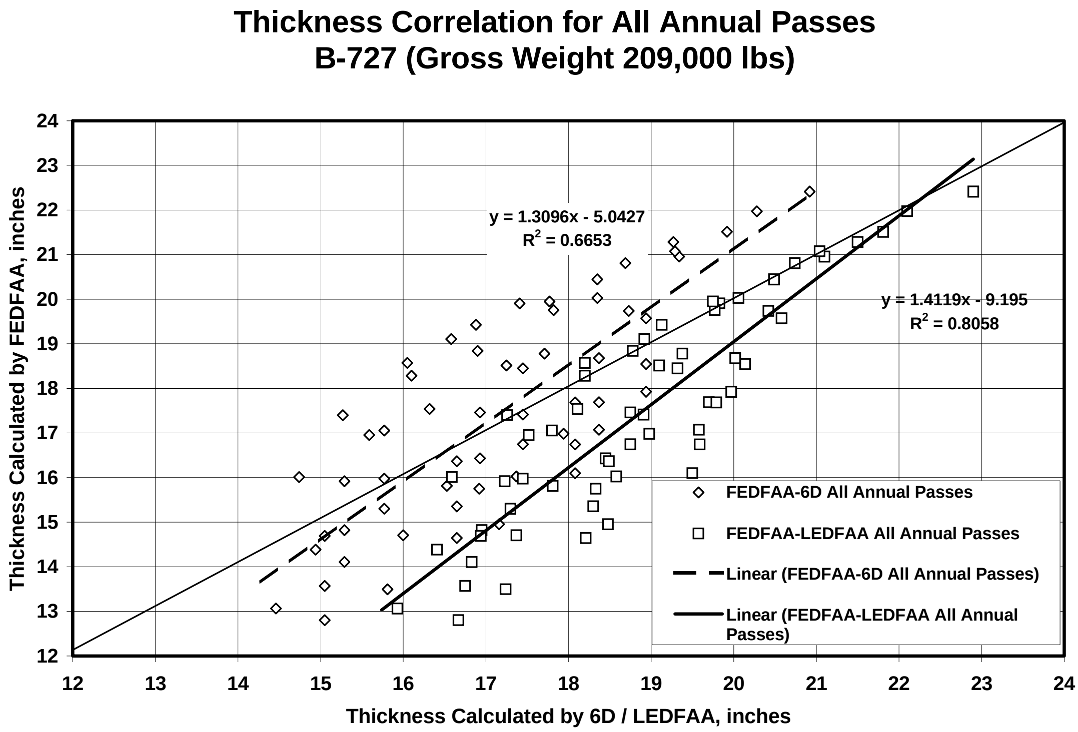

Figure 5. B-727 Thickness Correlation, Wheel Load 49,638 lbs

Aircraft Mix – Slab Thickness Difference

Figure 6 show the average slab thickness difference for all the new pavement structures (20) for the eight aircraft mixes:

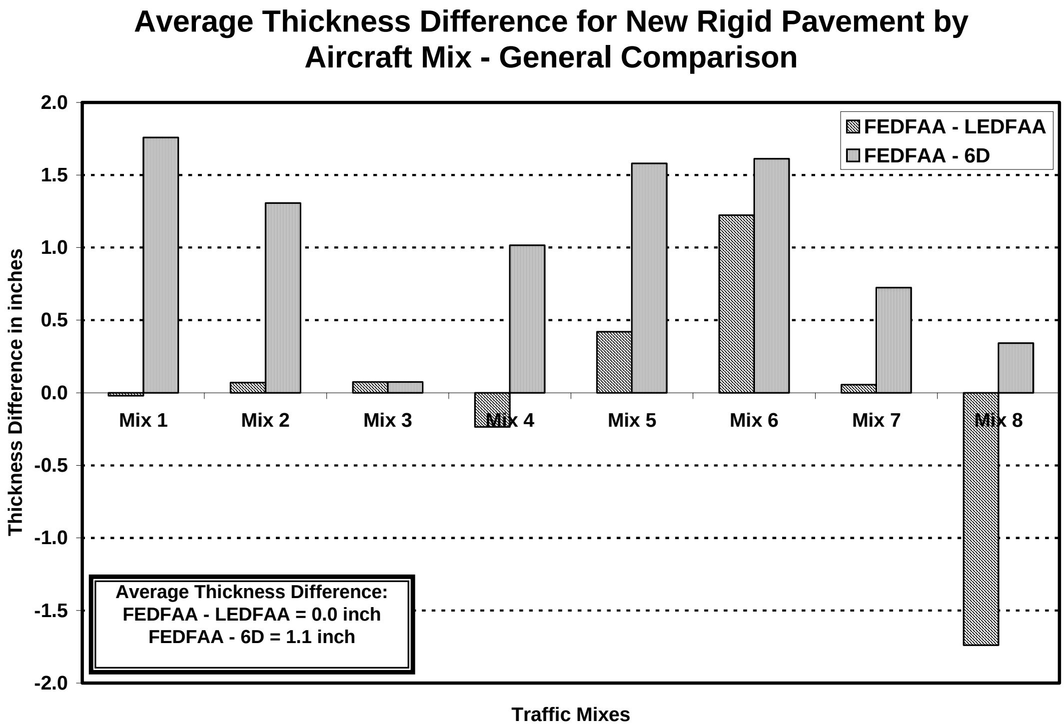

Figure 6. Average Slab Thickness Difference by Aircraft Mix

- The average thickness difference for FEDFAA-LEDFAA is 0.0-inch (0.0-mm) and FEDFAA-6D 1.1-inch (27.94-mm) for all the pavement structures.

- The thickness difference for FEDFAA-6D is consistently larger for the narrow-body mixes (1, 5 and 6). For the FEDFAA-LEDFAA case this is true only for narrow-body mixes 5 and 6. Mix 8 is the only wide-body mix that shows a large thickness difference for FEDFAA-LEDFAA.

The average slab thickness difference by aircraft mix for the pavement structures with only granular subbase is presented in Figure 7 for FEDFAA-LEDFAA and FEDFAA-6D:

- The difference is larger for FEDFAA-6D than FEDFAA-LEDFAA. This is an indicator that FEDFAA has a better correlation with LEDFAA than 6D.

- The thickness difference increases for all the mixes when the subgrade strength increases from very low to low, but decreases when the subgrade strength goes from low to high.

- The difference is larger for the narrow-body mixes 1, 5, and 6 for FEDFAA-6D and for mixes 5 and 6 for FEDFAA-LEDFAA.

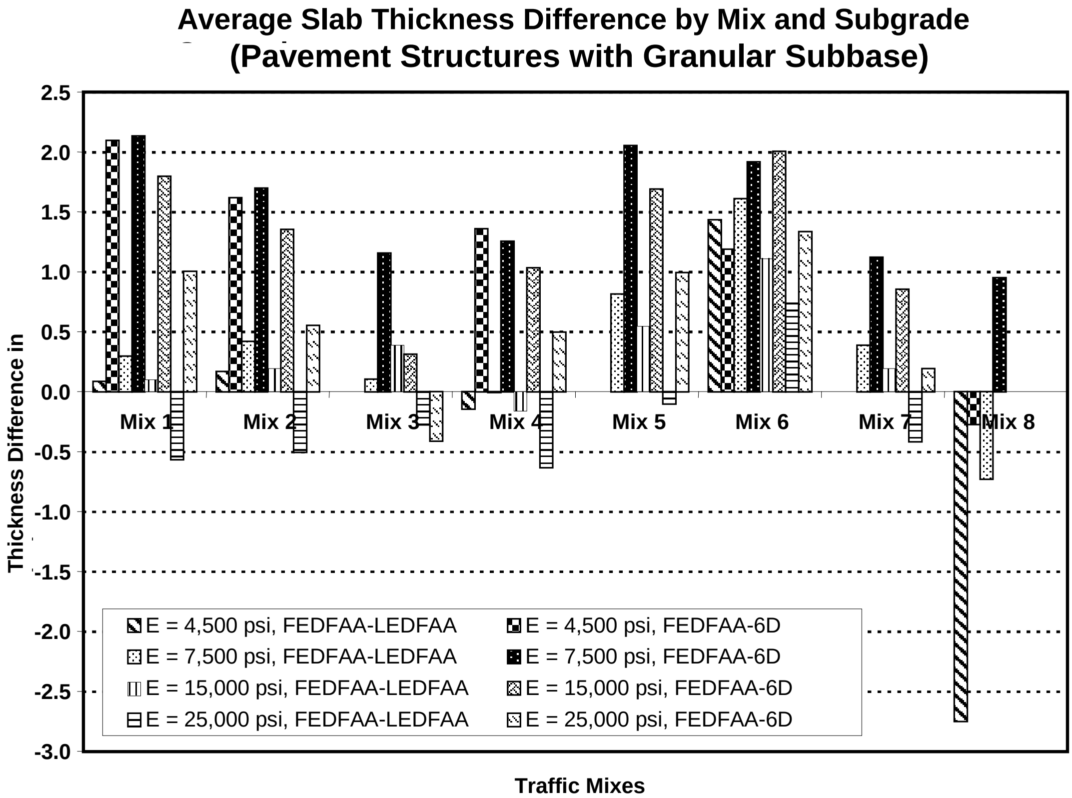

Figure 7. Average Slab Thickness Difference by Aircraft Mix and Subgrade Strength

The average slab thickness difference by aircraft mix for the pavement structures with stabilized subbase are presented in Figure 8 for FEDFAA-LEDFAA and FEDFAA-6D:

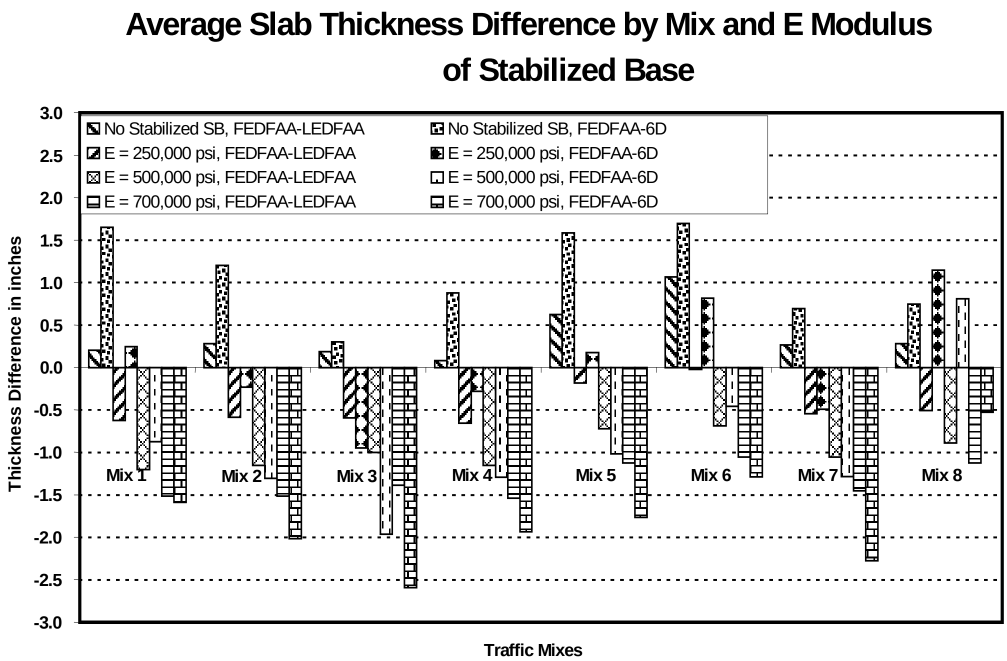

Figure 8. Average Slab Thickness Difference by Aircraft Mix and Stabilized Subbase

- FEDFAA correlates better with LEDFAA than 6D. The thickness difference is smaller for FEDFAA-LEDFAA for all the aircraft mixes regardless of the body size or stabilized subbase E value.

- The thickness difference decreases for all the mixes when the stabilized base E value increases.

- The difference is larger for the narrow-body mixes 1, 5, and 6 for FEDFAA-6D and mixes 5 and 6 for FEDFAA-LEDFAA.

NEW FLEXIBLE PAVEMENT DESIGN RESULTS

Pavement design thicknesses were computed using the 6D, LEDFAA Version 1.2, and LEDFAA Version 1.3 for different single aircraft and traffic mixes.

Single Aircraft Comparisons

Three different annual departure levels used were 120, 1,200, and 12,000. The results shown in this paper are for 1,200 annual departures. Figure 9 shows the percent difference between pavement thickness computed from LEDFAA Version 1.3-6D, and LEDFAA Version 1.3-LEDFAA Version 1.2 for pavements with 8-inch thick P-209 crushed stone base and for different aircraft.

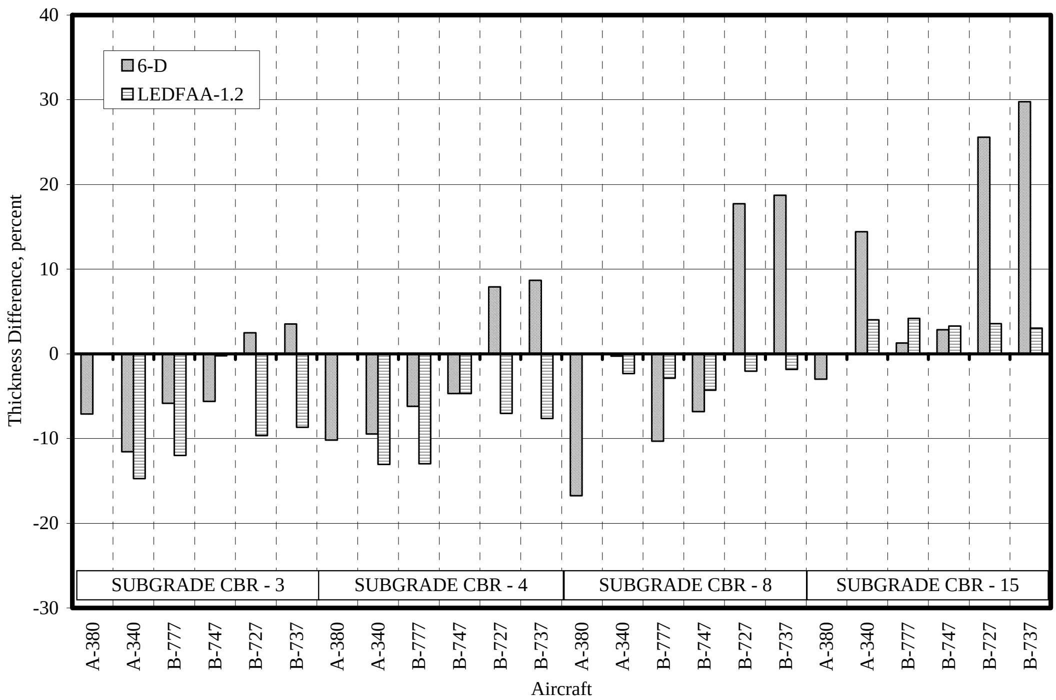

Figure 9. Difference between Pavement Thicknesses Computed from LEDFAA Version 1.3, 6D, and LEDFAA Version 1.2 for Pavements with 8-inch Thick P-209 Crushed Stone Base

The results show that for the low and medium strength subgrades (CBR=3, 4, 8), the LEDFAA Version 1.3 computed pavement thicknesses are less than 6D and LEDFAA Version 1.2 thickness for wide-body aircrafts. LEDFAA Version 1.3 thicknesses are up to 17-percent lower than 6D thicknesses and are up to 14-percent lower than LEDFAA Version 1.2 thicknesses. For the narrow-body aircraft (B-727 and B-737), the LEDFAA Version 1.3 thicknesses are up to 30 percent higher than 6D thicknesses, but up to 10 percent less than LEDFAA Version 1.2 thicknesses. For the high strength subgrades (CBR=15), LEDFAA Version 1.3 thicknesses are higher than the other two design procedures (6D and LEDFAA Version1.2) for most of the aircrafts.

Similar trends were observed in the case of pavements with 12-inch thick P-209 crushed stone base. Figure 10 shows the thickness difference results for pavements with 12-inch P-209 crushed stone base.

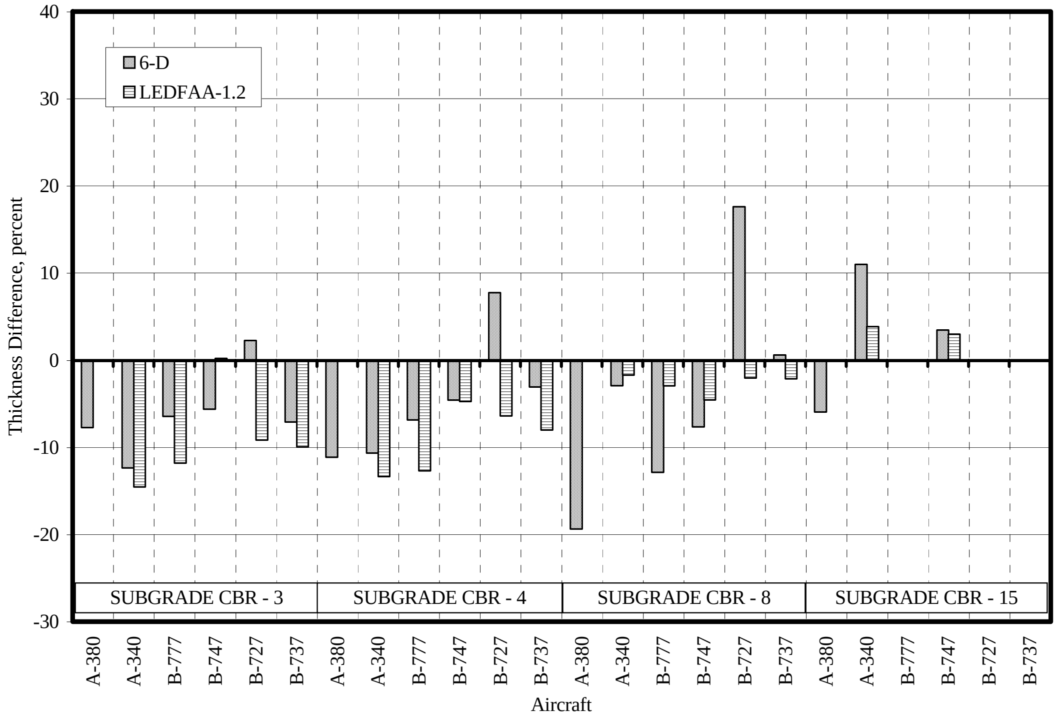

Figure 10. Difference between Pavement Thicknesses Computed from LEDFAA Version 1.3, 6D, and LEDFAA Version 1.2 for Pavements with 12-inch Thick P-209 Crushed Stone Base

Figure 11 shows the results for pavements with 5-inch thick P-401 asphalt stabilized base and for each single aircraft.

For the low and medium strength subgrades (CBR=3, 4, and 8) and for wide-body aircrafts, the LEDFAA Version 1.3 thicknesses are less than the 6D and LEDFAA Version 1.2 thicknesses. For the narrow-body aircraft (B-727, B-737), the LEDFAA-1.3 thicknesses are higher than the 6D thicknesses and lower than LEDFAA Version 1.2 thicknesses. For high strength subgrade (CBR=15), the LEDFAA Version 1.3 thicknesses are higher than the 6D and LEDFAA Version 1.2 thicknesses.

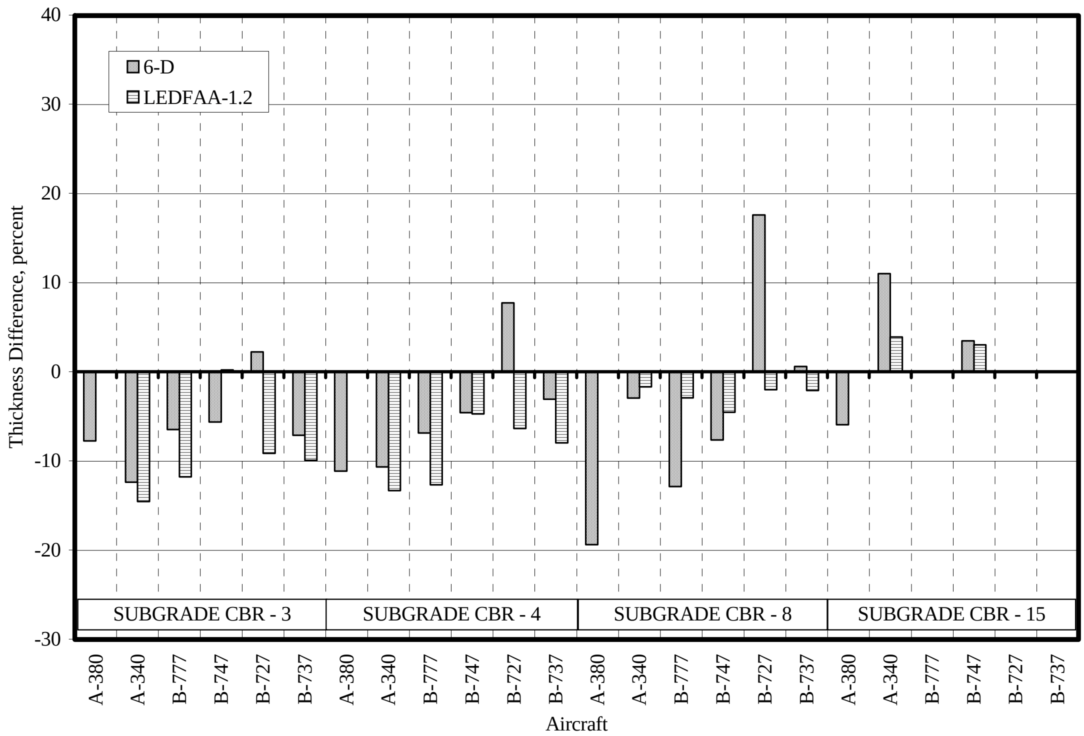

Figure 11. Difference between Pavement Thicknesses Computed from LEDFAA Version 1.3, 6D, and LEDFAA Version 1.2 for Pavements with 5-inch Thick P-401 Asphalt Stabilized Base

Similar trends are observed in the case of flexible pavements with 8-inch thick P-401 asphalt stabilized base. The results are shown in Figure 12.

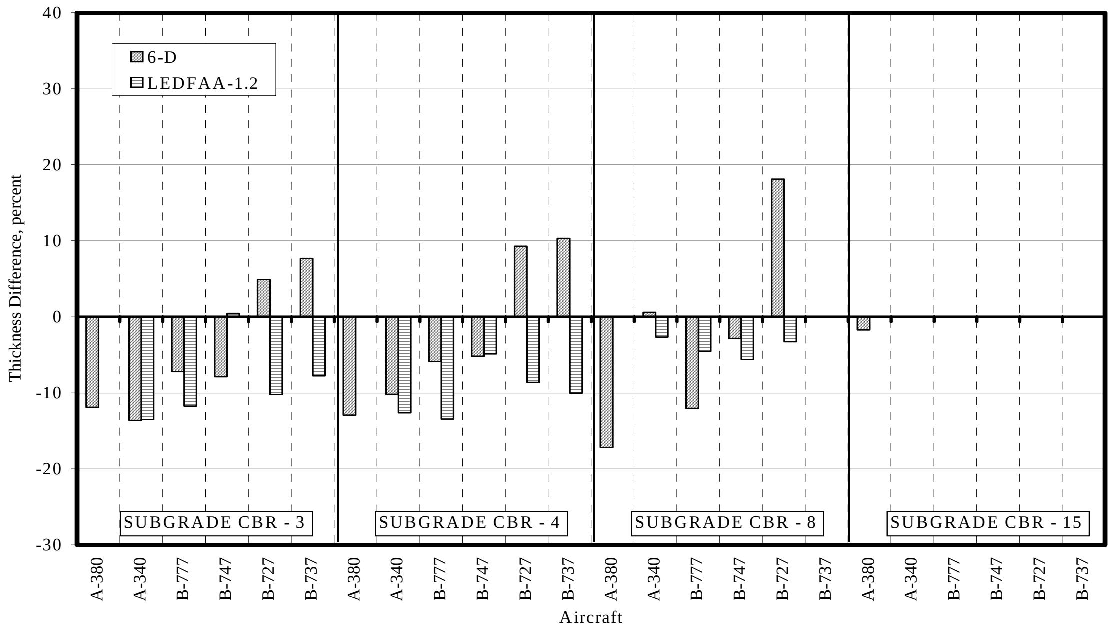

Figure 12. Difference between Pavement Thicknesses Computed from LEDFAA Version 1.3, 6D, and LEDFAA Version 1.2 for Pavements with 8-inch Thick P-401 Asphalt Stabilized Base

In general, for the low and medium strength subgrades, the LEDFAA Version 1.3 thicknesses are generally lower than the 6D and LEDFAA Version 1.2 thicknesses for wide-body aircraft. In the case of narrow-body aircraft, the LEDFAA Version 1.3 thicknesses are higher than 6D thicknesses but lower than LEDFAA Version 1.2 thicknesses. For the high strength subgrades, the LEDFAA Version 1.3 thicknesses are higher than the 6D and LEDFAA Version 1.2 thicknesses.

Traffic Mix Comparisons

The FAA design procedure is intended for designing airport pavements for traffic mixes. Aircraft traffic data from eight different airports were used for pavement thickness comparison. The traffic mixes consisted of both wide-body and narrow-body aircrafts. As previously discussed, of the eight traffic mixes, five traffic mixes were classified as wide-body mixes (wide-body aircraft dominate) and three traffic mixes were classified as narrow-body mixes (narrow-body aircraft dominate). Pavement thicknesses were computed from 6D, LEDFAA Version 1.2, and LEDFAA Version 1.3. Table 4 shows the Traffic Mix 1 for a narrow-body mix. Figure 13 shows the thickness comparisons for Traffic Mix 1. Similarly, Table 5 and Figure 14 show the Traffic Mix 7 (wide-body) traffic and thickness comparisons.

Table 4.
Traffic Mix 1 (narrow-body mix)

Aircraft No.	Aircraft Name	Gross Wt., lbs	Annual Departures
1	DC-9-30	90,700	24
2	B-737-200	115,000	979
3	DC-9-50	121,000	282
4	B-737-300	140,000	304
5	B-727	169,000	319
6	B-727	209,000	1,572
7	B-757	255,000	72
8	DC-8	276,000	10
9	BAe 146	70,000	51

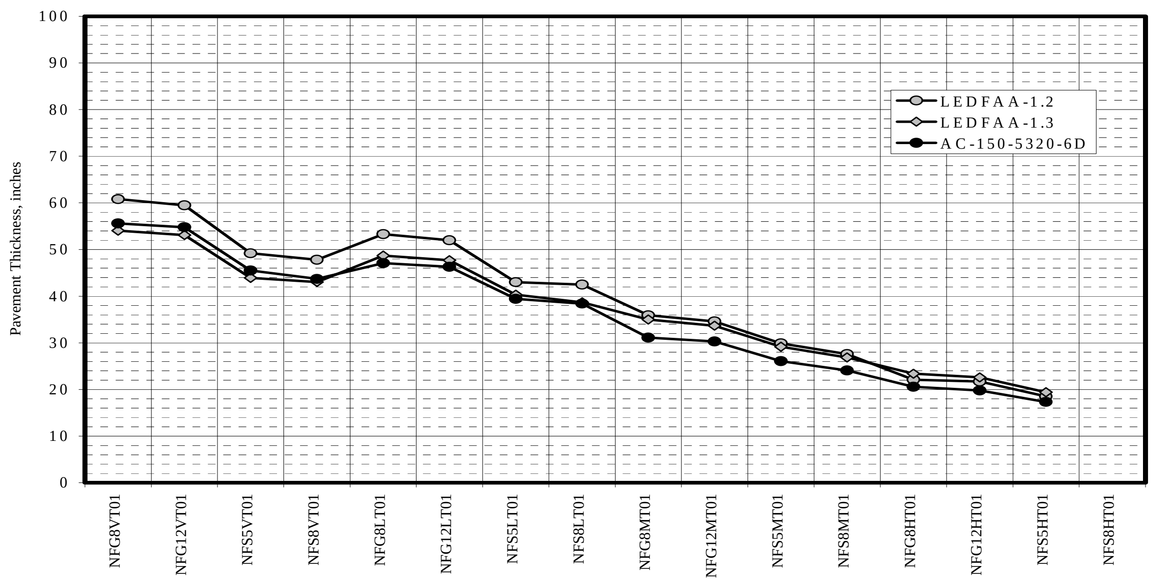

Figure 13. Thickness Comparisons for Mix 1

Table 5.
Traffic Mix 7 (wide-body mix)

Aircraft No.	Aircraft Name	Gross Wt., lbs	Annual Departures
1	B-727	209,500	4,958
2	B-737-400	150,000	23,356
3	B-747-200	870,000	832
4	B-757	255,500	3,427
5	B-767-200	350,000	5,061
6	DC-10-30	590,000	2,263
7	DC-10-30 Belly	590,000	2,263
8	DC-8	350,000	1,000
9	DC-9-50	121,000	6,086
10	MD-82/88	160,000	13,756

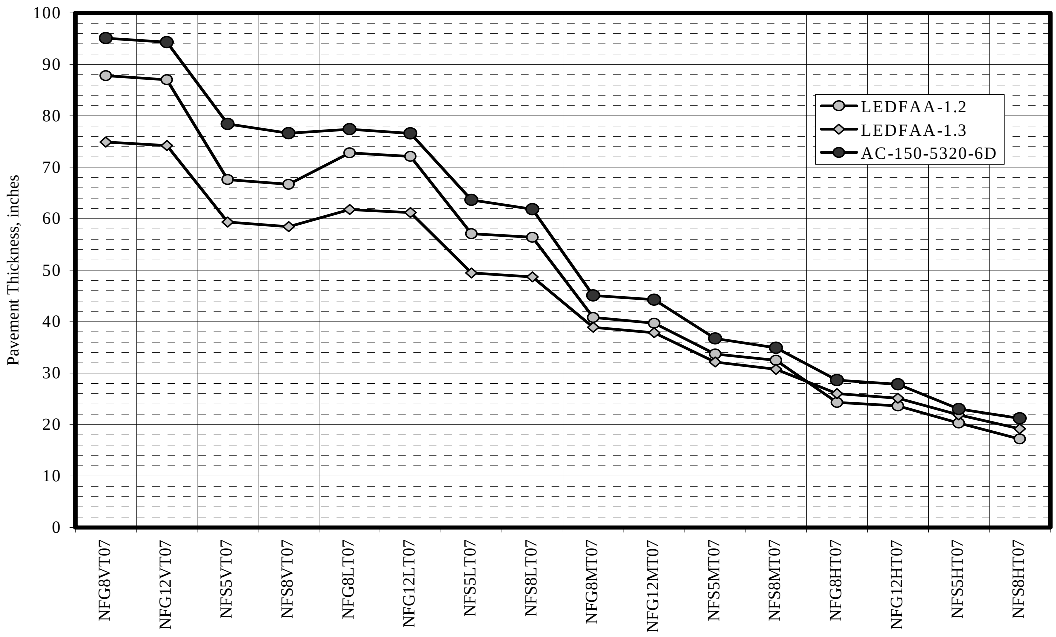

Figure 14. Thickness Comparisons for Mix 7

In Figures 13 and 14, the x-axis gives the pavement structure identification number. The first two characters denote the type of pavement (NF = new flexible), the third character specifies the base type (G=P-209 base, S=P-401 asphalt stabilized base), the number after G or S denotes thickness of base in inches, the character after the thickness denotes subgrade CBR (V=3, L=4, M=8, H=15), and the last three characters denote the mix number (in Figure 13, T01 means Traffic Mix 1 and in Figure 14, T07 means Traffic Mix 7).

Figure 13 shows that LEDFAA Version 1.3 thicknesses are lower than LEDFAA Version 1.2 thicknesses (CBR=3 and 4) and are similar at CBRs=8 and 15. No significant difference is observed between LEDFAA Version 1.3 and 6D thicknesses. Similar trends were observed for all the narrow-body mixes.

Figure 14 shows the thickness comparisons for Traffic Mix 7. The LEDFAA Version 1.3 thicknesses are less than 6D thicknesses for all subgrade strengths. LEDFAA Version 1.3 thicknesses are lower than LEDFAA Version 1.2 for CBRs=3, 4, and 8, and higher for CBR 15. Similar trends in thicknesses are observed for all the wide-body traffic mixes.

SUMMARY

Based on the comparative study results to date, the following observations can be made for the rigid pavement comparisons:

- For single aircraft comparisons, FEDFAA generally provides thicker slabs than 6D for both narrow-body and wide-body aircraft. However, the correspondence is closer for narrow-body aircraft.

- For single aircraft rigid pavement comparisons, FEDFAA and LEDFAA generally provide similar thicknesses for both narrow-body and wide-body aircraft.

- For the eight traffic mixes that were investigated, FEDFAA rigid pavement thicknesses were generally thicker than 6D thicknesses. The average slab thickness difference was about 1-inch.

- However, the FEDFAA-LEDFAA rigid pavement comparisons for the traffic mixes indicated similar thickness results from both methods. The average slab thickness difference was 0 inches.

Therefore, it can be concluded that for typical design application, i.e., those with a mix of aircraft traffic, FEDFAA designs correlative better with LEDFAA than with 6D for all traffic mixes regardless of body size.

For rigid pavements, work is continuing for rigid and flexible overlay design comparisons. Also, the FEDFAA failure criteria will be re-examined upon completion of the next series of full scale rigid pavement tests at the FAA’s NAPTF, scheduled for 2004.

Based on the results of the comparative study results for flexible pavements, the following observations can be made:

- For the single aircraft comparisons, LEDFAA Version 1.3 (which is incorporated in FEDFAA) thicknesses are generally less than 6D and LEDFAA Version 1.2 thicknesses for low and medium strength subgrades, but slightly thicker for high strength subgrade.

- For narrow-body traffic mixes, LEDFAA Version 1.3 thicknesses are less than LEDFAA Version 1.2 thicknesses for low strength subgrades and similar for medium and high strength subgrades. LEDFAA Version 1.3 and 6D thicknesses were comparable.

- For wide-body traffic mixes, LEDFAA Version 1.3 thicknesses are less than LEDFAA Version 1.2 thicknesses for low and medium strength subgrades and slightly thicker for high strength subgrades. LEDFAA Version 1.3 provides thinner wide-body flexible structures than 6D for all subgrade strengths.

Therefore, for flexible pavements, the revised subgrade strain criterion included in LEDFAA Version 1.3 generally results in thinner pavement structures than 6D and LEDFAA Version 1.2 for wide-body traffic mixes, and similar thicknesses for narrow-body traffic mixes. The revised failure criterion includes recent full scale test data from the FAA's NAPTF.

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